RADIONUCLIDE MEASUREMENTS BY ACCELERATOR MASS SPECTROMETRY AT ARIZONA. A. J. T. Jull, D. J. Donahue, and T. H. Zabel*. NSF Accelerator Facility for Radioisotope Analysis, University of Arizona, Tucson, Arizona 85721. *current address: IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598.

Over the past few years, Tandem Accelerator Mass Spectrometry (TAMS) has become established as an important method for radionuclide analysis. Measurements of ^{10}Be and ^{14}C are now routine in several laboratories (1). The basic principles of accelerator mass spectrometry have been reviewed by Litherland (2). All systems are basically similar in principle.

In the Arizona system (see fig. 1) we operate the accelerator at a terminal voltage of 1.8MV for ^{14}C analysis, and 1.6 to 2MV for ^{10}Be (3). Samples are inserted into a cesium sputter ion source in solid form. Negative ions sputtered from the target are accelerated to about 25kV, and the injection magnet selects ions of a particular mass. In the case of ^{14}C, N does not produce negative ions and an important source of background is eliminated. The ions are accelerated to the terminal potential of up to 2MV. They then pass through a stripper canal, losing electrons. The resultant positive ions are then accelerated back to ground. Ions of the 3+ charge state, having an energy of about 8MeV are selected by an electrostatic deflector, surviving ions pass through two magnets, where only ions of the desired mass-energy product are selected. The final detector is a combination ionization chamber to measure energy loss (and hence, Z), and a silicon surface-barrier detector which measures residual energy. After counting the trace iosotope for a fixed time, the injected ions are switched to the major isotope (^{13}C or ^{9}Be) used for normalisation. These ions are deflected into a Faraday cup after the first high-energy magnet (M1). Repeated measurements of the isotope ratio of both sample and standards results in a measurement of the concentration of the radionuclide.

An important part of TAMS dating is the ability to produce accelerator targets on a consistent and routine basis. For ^{14}C, graphite is the best target because of its high negative ion yield and stability for extended periods of time. Recent improvements in sample preparation for ^{14}C (4) make preparation of high-beam current graphite targets directly from CO_2 feasible. Routine measurements up to now at Arizona have been made on iron-carbon targets, made by dissolution of about 1 mg carbon in 15 mg iron (5). The ^{14}C background using this method is equivalent to approximately 2% modern carbon. This level is almost entirely due to ^{14}C introduced during sample preparation. Lower backgrounds of as low as 0.4% modern carbon ($^{14}C/^{12}C = 4 \times 10^{-15}$) have been measured from carbon produced directly from CO_2/H_2 gas mixtures. If the background level is constant, it can be subtracted, and the detection limit is the error in the background (2 sigma).

Extraction of spallogenic ^{14}C from rocks and meteorites (6) requires temperatures at or near the melting point and oxidising conditions to ensure complete extraction of ^{14}C. By contrast, the chemistry for extraction of ^{10}Be is relatively standardised, the only criterion is to limit contamination by the isobar ^{10}Be.

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Except for some measurements of standards and backgrounds for ^{10}Be, our measurements to date have been on ^{14}C. We expect to have more ^{10}Be measurements in the near future. The facility at Arizona has produced a large amount of data on ^{14}C. Although most results have been in archaeology and quaternary geology (3,7), we have expanded our studies to include cosmogenic ^{14}C in meteorites, in collaboration with Fireman (8). The data obtained so far tend to confirm the antiquity of Antarctic meteorites from the Allan Hills site. Data on three samples of Yamato meteorites gave terrestrial ages of between about 3 and 22 thousand years. More samples need to be studied, and comparisons made with other cosmogenic nuclides on the same material, before conclusions as to the terrestrial age distribution of the Yamato collection. The study of samples exposed to simulated cosmic-ray irradiation should also aid in the intercomparison of data on different radionuclides.

References.

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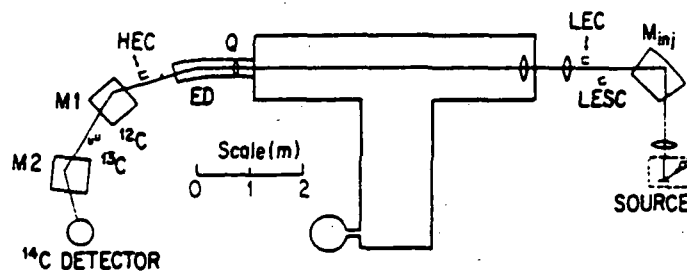8.) Jull, A. J. T. et al. (1984), Proc. Lunar Planet. Sci. Conf. 15th, in press.

Figure 1. Schematic diagram of system. Abbreviations in the figure are: M$_{inj}$, injection magnet; LEC, low-energy Faraday cup (this cup can be moved in and out of the beam); LESC, low-energy side cup; Q, electrostatic quadrupole focus; ED, electrostatic deflector; M1 and M2, high-energy magnets, ^{13}C and ^{12}C, high-energy Faraday cups.